SOME PARTLY DISSECTED PLAINS IN JO DAVIESS COUNTY, ILLINOIS[1]

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Jo Daviess County is the northwesternmost county in Illinois and adjoins northeastern Iowa and southwestern Wisconsin. The county is partly covered by the Galena and Elizabeth topographic sheets of the United States Geological Survey. The topography of this county occupying the southern part of the driftless area has remained unaltered by the ice invasion and is still exposed for physiographic study. The writer, in company with E. W. Shaw and B. H. Schockel, spent a large part of the field season of 1910 in Jo Daviess County in co-operative work between the United States Geological Survey and the Illinois Geological Survey, and the following paper is one result of that work.

Rock formations appearing at the surface in the district are of Ordovician and Silurian age, and are classified as follows:

Name of Formation	Kind of Rock	Thickness
Niagara	Dolomite	140 feet
Maquoketa	Shale	108–209 feet
Galena	Dolomite	240 feet
Platteville	Limestone	50 feet

All of these formations occur at the surface over wide areas, with the exception of the Platteville, which is found only in the valley of Galena River in the northern part of the district. The strata have a general dip to the southwest of about 17 feet to the mile, and on this monoclinal structure are a series of slight, hardly noticeable anticlines and synclines.

The most conspicuous topographic feature in the county, aside from the bluffs of the Mississippi Valley, is a more or less

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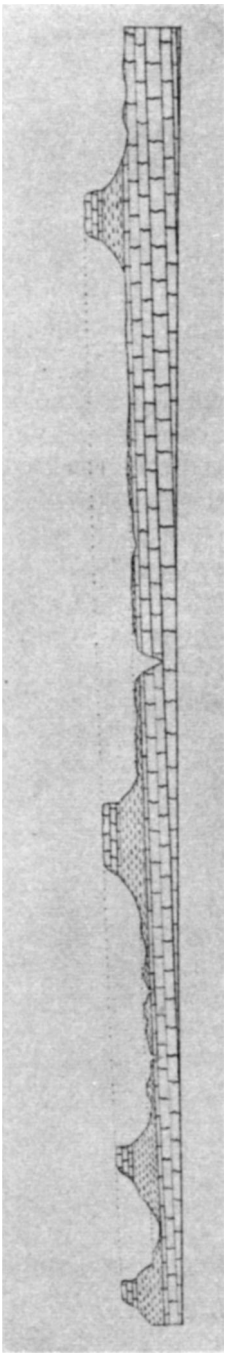

FIG. 1.—A diagram showing the relations of the Niagara and Galena plains to each other and to the rock structure of the district. The upper dotted line represents the Niagara plain, and the lower dotted line the Galena plain. The uppermost rock formation is Niagara dolomite and the lowermost is Galena dolomite. Between the two is the Maquoketa shale, represented by dashes.

extensive and definite plain midway between the skyline and the valley bottoms. Its surface is broken by mounds and ridges above it, and by many sharp valleys below it. For convenience this may be called the *intermediate plain*. The mounds and ridges which stand on the intermediate plain and whose tops form the upland come up to a somewhat common level, in such a way that if the low land were filled up to their tops the region would be a nearly flat plain. The upper dissected plain lies everywhere on the Niagara dolomite, and the intermediate plain follows more or less closely the surface of the Galena dolomite; hence the upper plain is here called the *Niagara plain* and the intermediate surface the *Galena plain*. These two plains, the first now almost entirely dissected and the latter somewhat but less so, constitute the problems of this paper. Their general relationships are shown in Fig. 1.

The Niagara plain was known to Hershey[1] as "Peneplain No. 1," and he considered it to be a true peneplain partly dissected, of Cretaceous age. Bain[2] mentions the plain and seems to agree with Hershey concerning it. The upper plain was also known to Grant and Burchard[3] who state that "the facts observed

[1] *Am. Geologist*, XVIII, 75–78.

[2] *Bull. U.S. Geol. Surv. No. 294*, p. 15.

[3] *Lancaster-Mineral Point Folio*, U.S. Geol. Surv., p. 2.

within these two quadrangles are not sufficient to determine whether the upper plain—that is, the one lying above the Niagara escarpment—is a peneplain or a structural plain, and its general history outside of these two quadrangles has not yet been completely worked out, though its age is probably Cretaceous." A plain probably to be correlated with the Niagaran plain was recognized and called the "Allamakee Peneplain" by Calvin[1] in his report on Allamakee County, Iowa. The intermediate plain has been referred to by Hershey as "Peneplain No. 2," and by Bain, and by Grant and Burchard as the "Lancaster Peneplain," and it has been assigned by them to the Tertiary period. Calvin and Leonard make no note of such a plain in the reports on Allamakee and Clayton counties in Iowa. The Cretaceous and Tertiary ages of these respective plains seem to have been tentatively established by their relation to Cretaceous deposits in Minnesota and Iowa, and to Tertiary deposits in the Gulf region. There is little or no evidence of the dates of formation of the plains in Jo Daviess County, and their ages do not form the problems of this paper.

It seems advisable here to describe and interpret these plains, as seen in Jo Daviess County, with a view to determining if there are any other possible explanations beside that of peneplains. The purpose of the discussion is twofold. First, it is hoped that it may lead to a true interpretation of these plains and an understanding of the physiographic history of the region in which they are found. Secondly, an attempt is made to bring out the criteria for distinguishing upland plains of certain origins and histories from those of other origins and histories. It is believed that criteria for distinguishing raised and partly eroded peneplains in regions of folded strata, such as the Appalachian Mountains, are fairly well worked out; but that many of these criteria will not apply in regions of horizontal or nearly horizontal structures, and that the characters of peneplains in such regions are not so well known as they should be and have not been given as critical study as they deserve.

THE NIAGARA PLAIN

In most places where the Niagara dolomite is found in Jo Daviess County, its top has an even skyline when seen from a distance and a flat surface as seen when it is traversed. It is always a hard

[1] *Geology of Allamakee County*, p. 43.

pull for a horse when one is driving up the upper slopes, but, once the top is reached, the road has little grade. This can be well seen on the upland over the Great Western tunnel, or on the hills around Elizabeth, or almost anywhere on the upland surface. Even in the north part of the district the Niagara-capped mounds are flat topped, and those which stand in east-west lines come up to almost a common level. It is clear that if all the valleys were filled up to the tops of the mounds, the resulting surface would be nearly flat, and the presumption is strong that there was once a plain here which has since been dissected. The mounds in the north part of the district reach elevations of 1,170, 1,152, 1,160, etc. In the central part, the mounds and the tops of the Niagara-capped ridges reach 1,112, 1,145, 1,065, 1,060, 1,072, etc. In the south portion of the district, considerable areas of the plain are found at 944, 964, 1,027, 1,004, and 1,000 feet. That is, if this plain were reconstructed, it would slope south and southwest about 175 feet in 16 miles, or about 11 feet to the mile. In Wisconsin, a few miles north of this district, this same surface on the Niagara dolomite reaches elevations of 1,400 feet, showing a continued rise in that direction. It is seen then that this plain, if reconstructed, would slope in the direction in which the rock strata dip and at about the same angle.

The origin of this plain is now in question. There are at least four possibilities: (1) it is an old peneplain uplifted and dissected after its formation by streams; (2) it is a plain made by a hard layer of rock at this stratigraphic horizon; (3) it is the original sea bottom which, after emerging, remained low and flat for a long time after the Niagaran epoch; or (4) it is the result of the erosive action of ocean waves cutting back on the land, at a time subsequent to the deposition of the Niagara dolomite and any other formations which may have been laid down on it, the present remnants resulting from the partial erosion of the surface by streams following uplift relative to the sea. The correct one or ones of these four hypotheses ought to be determinable by close field observation.

1. If such a flat is a dissected peneplain, (*a*) it is likely to have hills standing above it, which were left unreduced in the former cycle of erosion; (*b*) the surface is likely to have some relief; (*c*) the

thickness of the formation on which it is developed is likely to vary to a degree corresponding with the relief of the surface; (*d*) it is not likely to be parallel to underlying strata, but to rise or fall stratigraphically; (*e*) it would be expected to slope in the general direction, corresponding to the direction of flow of the streams that made it, unless tilting took place after its formation; (*f*) much of the plain might be covered with river detritus such as fine gravel, sand, and silt, similar to the materials of river-made plains today. If such a plain is not parallel to underlying strata, but lies across their beveled edges, particularly if the strata are known to have constant thicknesses where undisturbed, it is almost certainly a result of erosion going to a late stage—a peneplain. This might not hold if the strata were the result of near-shore deposition, and thinned out shoreward.

If the characteristics of the Niagara plain be compared with this set of features expected on a raised and partly dissected peneplain, they are found to correspond only in part. Concerning the plain as it is in these quadrangles, (*a*) no distinct hills stand above it; (*b*) the flat has little relief—probably no more than could have been given it by erosion following the uplift; (*c*) the thickness of the formation under it varies slightly but not greatly in short distances; (*d*) its surface does not rise or fall appreciably in the stratigraphic section, even when considerable distances are considered; (*e*) it does slope in a general direction and at about the angle expected for a peneplain; (*f*) no sand or gravel or stream alluvium were discovered on the flat, and it is certain that no great amount of such material was there and has been subsequently removed, for it is not found on the bordering slopes, and some of the plain has been unaltered by any agent which could remove the alluvium. From the foregoing, it is seen that this plain is not clearly a raised peneplain; neither is it surely not a peneplain. If traced beyond the limits of this region, and found there to go from Niagara to Maquoketa to the north and from Niagara to something younger to the south, it will have been proven, nevertheless, to be a peneplain.

2. In a second cycle of erosion, a flat of considerable magnitude might be formed on the top of a hard layer of rock, by the removal

of softer material from above, provided the streams were not able to cut through the hard formation for a long period of time. Such a plain would be essentially a peneplain, with the difference that its position is determined by a hard stratum, instead of by base level, and that it would require no uplift to start its dissection; dissection would result when the main stream had cut through the hard formation. It would have essentially the same characteristics as a true peneplain, with the marked exception that it would be parallel to the layers of rock, and remain at the same stratigraphic position over wide areas.

If the Niagara plain be tested by these criteria, again no definite conclusion can be drawn. As the flat is everywhere located on the Niagara, lies everywhere near the top of the massive member of that formation, and about 150 feet above its base, and as it has all the other characteristics of a true peneplain, it may be said to fit the second hypothesis better than the first.

3. Or is the Niagara plain the original surface which emerged from the sea at the end of the Niagaran epoch, and has suffered dissection since then? A surface having had such a history should have somewhat different characteristics from one developed in either of the ways previously outlined. (*a*) There would be no marked hills standing above the remnants of the plain, for there were no other strata above it from which hills could have been formed. (*b*) The thickness of the underlying formation would be expected to be uniform, except for possible differences in the amount of deposition on the bottom of the sea, or erosion since emergence from the sea. (*c*) The plain would have little or no relief, unless roughened after its emergence, by streams, wind, etc. (*d*) Like the plain developed on a hard layer, the surface would follow the rock structure, not rising or falling appreciably with reference to the strata. (*e*) Any slope the plain has would be the slope, in direction and amount, of the old sea bottom, unless tilting occurred during emergence or later. (*f*) No river detritus should be found on this surface, but instead material deposited at the shoreline as the shore receded over it, if anything. (*g*) In this case also, if the bottom of the old sea has been preserved as the plain, it might be expected that somewhere the old shorelines might be found as raised cliffs,

old beaches, etc., in places where protected from later erosion. (*h*) Marine fossils might be found on the surface of the plain.

Of these features the plain under discussion has some and lacks others. (*a*) It has no hills above it; (*b*) the underlying formation has a sufficiently uniform thickness to give the idea of an original plain; (*c*) the relief of the surface is sufficient but not too great; (*d*) the plain follows the structure fairly closely; the slope of the flat may be either that of the old sea bottom, or the result of slight subsequent tilting; (*f*) and (*h*) the materials of the surface afford no evidence, because there is a complete lack either of river detritus or of the shells of terrestrial or marine animals; (*g*) even if old shorelines were preserved at the edge of the ancient sea bottom, they would be found only at the margin of the plain, and this is outside the region under discussion. But no such shore features have been reported, and in all probability none exists. Even if the plain had had such a history as is here outlined, the factors mentioned in (*f*), (*g*), and (*h*) would not be expected to have persisted through such a lapse of time as the hypothesis presupposes.

4. There remains one other hypothesis to be analyzed and tested. If this plain is the result of marine erosion, it would have most of the characters of a peneplain due to stream erosion; that is, (*a*) it might have erosion remnants on its surface; (*b*) it might lie parallel with the strata in a general way, but it would be surprising if the two were exactly parallel; (*c*) it would slope in one general direction, in this case the slope being the oceanward slope of the old sea bottom; (*d*) some of the plain should be covered with marine sediments—debris deposited on the surface after its erosion, but before the recession of the sea. This plain would differ from a true peneplain in having little or no relief before dissection, and in having correspondingly little variation in thickness of the underlying formation within short distances. In addition, a plain so made must have been bounded originally by a shoreline of some sort, and this might or might not have been preserved, if the flat was preserved. Also, as the sea cut its way over the rock surface, and the flat off shore became wider and wider, the places eroded would gradually become sites of deposition, and this débris might

be found on the plain, either cemented into hard rock or uncemented.

Again the Niagara plain has some of these characters, but not all. So far as slope and the apparent original relief and the uniformity of thickness of the underlying formation are concerned, the plain might be explained along the lines of this hypothesis, but the correspondence of the surface with the structure of the beds, the absence of near-shore marine deposits, the absence of all shorelines, and the fact that no other large plains are known which seem to have been made in this way, would seem to point to some one of the other hypotheses as the true explanation of the flat.

Conclusion.—After this discussion it is apparent that the origin of the Niagara plain is from this region not perfectly clear, but that some speculation at least is warranted. The facts that the plain is so distinctly related to structure and that it shows no conclusive evidence of having been peneplained point toward the conclusion that it is the original plain or a structural plain (or both), rather than an old peneplain or a plain of marine erosion. It is unlikely that a peneplain would happen to be formed so closely parallel to structure as this flat is *over wide areas*. Still it is possible that, when traced into other regions, this parallelism will fail, and the flat will be proven to be a peneplain. It has been so long since the Niagaran epoch, that it appears extremely unlikely that a flat emerging from the sea at that time could have remained undestroyed until now, unless perhaps it be conceived that the surface took a position very near to sea-level from the start, and held that position until uplifted in relatively recent times. Perhaps it is a combination of a true peneplain and a structural plain, the flat having been developed on the hard Niagara dolomite at a level which was near grade for the streams of the region at that time. Possibly the flat is an original marine plain and also a structural plain, the last deposit in the sea having been made into hard rock (the massive Niagara). Most likely the plain under discussion is an ordinary structural plain, the surface having been developed due entirely to the hard Niagaran dolomite which held up the streams at that level until all overlying strata were removed, before the dolomite formation was finally cut through and dissection of the plain began.

THE GALENA PLAIN

The Galena plain is best developed and distributed over widest areas and can be seen to best advantage in the district around the towns of Scales Mound, Apple River, Warren, and Stockton. Here is a surface 150 feet lower than the tops of the mounds and ridges of the Niagara plain, and 150–200 feet above the stream beds. Except for the elevations above it and the depressions below it, the plain forms a wide area of slight relief. In Section 8, Rush Township, where its surface has not been modified, it has a relief of less than 20 feet for a whole mile. This is a little more flat than the average, but not greatly so. This plain is practically confined to the northern two-thirds of the county; it does not appear to any appreciable extent in the southern one-third, and is lacking entirely along the south edge of the Galena and Elizabeth quadrangles. In the vicinity of Galena it appears in flattish or rounded divides midway between the upland mounds and the valley bottoms. By close observation, similar features may be seen about as far south as the Great Western tunnel in the Galena quadrangle, and to about the latitude of Stockton in the Elizabeth quadrangle. If reconstructed, this plain also would slope southward at a low angle.

Stratigraphically, the Galena plain is located on the hard Galena dolomite or only slightly above it in the Maquoketa shale. The broad flat in the district around Scales Mound, Apple River, Warren, and Stockton is underlain directly by the upper thin beds of Galena, or locally far from the main streams by 5–15 feet of Maquoketa shale above the Galena. The rounded divides and narrow flats around Galena and north and south of that place are underlain by Maquoketa shale of thicknesses up to 30 feet. In the south part of the county where the Galena dolomite dips beneath the surface, the flat cannot be seen.

In the case of the Galena plain, only three of the four above-discussed means of origin are possible. It cannot be an original marine plain of deposition, because the mounds and ridges of Niagara dolomite stand above it, and have been made by processes of degradation since the recession of the sea. It may, however, be a structural plain on the hard Galena dolomite, or it may represent the beginnings of a true peneplain, or perhaps it is conceivable that it was carved out from the shale and dolomite above the Galena

by the waves of a slowly advancing sea. In either of the first two cases, streams were the agents of its formation, the cause of the flat only being different. If a structural plain, the flat was developed by streams, because they flowed down the dip of the top of the hard dolomite, scouring off the softer shale. If the flat is a remnant of a true peneplain in its beginnings, it was developed by streams because they had reached grade, and the region had been developed to an early peneplain stage before uplift allowed dissection in another cycle of erosion.

After analysis of the various features of this plain, the idea of marine erosion seems to be untenable. On such an extensive plain, marine near-shore deposits would have been sure to be deposited, and no suggestions of such deposits are found on the surface. Under this hypothesis, also, the mounds and ridges standing on the plain must have been islands, headlands, peninsulas, etc., and their sides must have suffered erosion by the waves which made the plain; that is, their sides must be shorelines of erosion. As most of these elevations stand out boldly on the plain, far from the main streams and valleys of the present cycle of erosion, it must be considered that they are about as they were left by the agent or agents which made them. This being the case, evidence of the work of waves on their sides should be visible now. But in contrast to this, the slopes of these mounds and ridges show every evidence of stream work, and have very clearly not been eroded to their present shape by waves; especially is this true in the central and southern parts of the county where the uplands form the stream divides and have the dendritic arrangement characteristic of topographies developed by the work of streams.

The Galena plain has all the main earmarks of an incipient peneplain after uplift and partial dissection, except that it follows the Galena dolomite with surprising closeness: (1) it consists of extensive flat areas lying between uplands and lowlands, and in such positions flat areas are not developed except for some special reason; (2) aside from recent dissection, it has about the flatness to be expected on a peneplain; (3) distinct erosional hills stand above it; (4) it slopes gently in the direction in which the present streams flow; but (5) it follows the top of the Galena formation

rather closely, and seems to disappear where that formation dips beneath the surface. However, close study of stratigraphy in connection with this flat shows the coincidence of flat and structure to be not so striking after all. In southwestern Wisconsin, Grant and Burchard[1] find evidence of a dissected peneplain on the upper part of the Galena formation, which now has an altitude of 1,000–1,100 feet. In the northern part of Jo Daviess County this surface is above a few feet of Maquoketa, and the shale formation gets slightly thicker under the flat to the south. That is, to a small degree the flat does lie across the beveled edges of different formations. These relationships are shown in Fig. 1. The Galena plain is believed by the writer to have been a true but only partly developed peneplain, but one somewhat controlled by rock structure.

The feature which seems at first to militate against the peneplain interpretation is the disappearance of the flat where the Galena dolomite dips below the surface. However, this may be explained. If the peneplain was developed on the Galena and Maquoketa formations as shown in the diagram (Fig. 1), the Maquoketa shale was thickest under the southern part of the plain. When the plain was uplifted and the streams were rejuvenated, the shale was attacked most vigorously downstream. The shale being soft, its dissection resulted in speedy destruction of the plain where the shale was thick; where lacking, the plain was preserved longer. Even where there was a little shale under the plain the main streams cut through it rapidly, and then were held to slow cutting by the hard Galena dolomite. Working in the hard rock, they did not send out tributaries as readily as they did in the soft shale farther south, and the flat was protected. It is believed then that the plain is a partly developed peneplain, the southern part of which, after uplift, has been destroyed because the shale which underlay this part was exposed and not resistant to erosion. The plain is more distinct in the central part of the district, and in the northern part it is very well preserved, because of the hard dolomite near or directly under it. Possibly also the dolomite had some influence in the development of the plain as well as in its modification.

[1] *Lancaster-Mineral Point Folio*, U.S. Geol. Surv., p. 2.

CONCLUSIONS

The mounds and ridges in Jo Daviess County, Illinois, are remnants of a plain which is either an old peneplain or a structural plain, and in the mind of the writer the latter interpretation is more likely to be correct than the former. It is probable that the district remained under the sea for some time following the deposition of the Niagaran rocks now found here, and that emergence took place some time after the Niagaran epoch. The region was then subjected to erosion, and a broad plain was developed on the hard Niagara dolomite. Finally this formation was cut through by the major streams, and the Maquoketa shale underlying was rapidly removed. The streams reached grade at the level now represented by the Galena plain, which in this district happened to lie in the upper part of the Galena formation and the lower part of the Maquoketa shale. Before the mounds and ridges on this plain had been brought low, probably in Tertiary time, an uplift occurred and the streams were again allowed to deepen their valleys in the old plain.

It is realized that a close study of these plains over wide areas will be necessary before a complete understanding of them is obtained. The whole driftless area seems to be the field of work. The writer hopes to do something more toward the solution of the problem at a later date.